

# KARYOTYPIC CHARACTERISTICS OF *SOREX TUNDRENSIS* MERRIAM (MAMMALIA: SORICIDAE), A NEARCTIC SPECIES OF THE *S. ARANEUS*-GROUP

V. R. Rausch and R. L. Rausch

*Abstract.* — The karyotype of *Sorex tundrensis* Merriam, 1900 is redefined on the basis of a female specimen from Alaska, and compared with those of taxa in Eurasia that have been regarded as conspecific. The diploid number ( $2N = 32$ , FN autosomes = 58) comprised 28 bi-armed autosomes (14 homologous, nonpolymorphic pairs) wherein centromeres are median to subterminal, 2 autosomes (1 pair) with centromeres nearly terminal, and the X-chromosomes (the two largest elements in the complement). The diploid numbers of Eurasian shrews referred to *S. tundrensis* have been found (from the literature) to range from 31 to 40 in males (with the male trivalent sex-chromosomes typical of the *S. araneus*-group); their karyotypes usually include a larger component of acrocentric elements, and the fundamental numbers (autosomes) have been calculated to be 52 or 54. The Eurasian taxa appear to make up a complex of morphologically similar sibling species. The significant differences between the North American and Eurasian taxa in number of major chromosomal arms and other characteristics indicate that *S. tundrensis* is limited geographically to the Nearctic. The taxonomic problems involving *S. tundrensis* and *S. arcticus* Kerr, 1792, both nearctic members of the *araneus*-group, are briefly reviewed.

---

The mammalian fauna of North America north of ca. lat. 45°N includes two species of shrews placed in the *Sorex araneus*-group (characterized by trivalent sex-chromosomes in the male), *Sorex arcticus* Kerr, 1792 and *S. tundrensis* Merriam, 1900, of which the latter has been considered to have an holarctic distribution (see Junge et al. 1983, for review). That these two taxa represent independent species was denied for some years because of differing opinions concerning the significance of macromorphological and morphometric characters. Chromosomal comparisons have made clear that *S. arcticus* does not occur in Eurasia. Some uncertainty exists concerning the relationships of taxa designated *S. tundrensis* in the Holarctic, since the karyotype of the nominate taxon in northwestern North America has not been fully described.

Herein, we define the chromosomal char-

acteristics of *S. t. tundrensis* from Alaska, based on one female specimen. The findings supplement the observations and conclusions of Meylan & Hausser (1991), who presented the diploid chromosomal complement of a male *S. tundrensis* collected in the Yukon Territory.

## Materials and Methods

A female *Sorex tundrensis* was captured in August 1990 in the Matanuska Valley of south-central Alaska (approx. 61°39'N, 149°12'W). After colchicine and hypotonic treatment, cells from marrow and lymphatic tissue were centrifuged, fixed, and placed on slides in the field; the slides were later stained in the laboratory at the University of Washington. Procedures applied in the preparation of mammalian chromosomes have been described in detail else-

where (Rausch & Rausch 1975). To produce Giemsa-banding, the method of Seabright (1972) was used. Chromosomes were counted and evaluated in more than 50 intact cells in metaphase stage; 25 cells were photographed, from which, in non-banded complements, chromosomal measurements were made as suggested by Levan et al. (1964). In 15 karyograms constructed for comparisons, arm-ratios and size provided the basis for assembling pairs of non-banded complements, and those with G-bands were sorted by size and banding-pattern. The fundamental number (FN) of major chromosomal arms was determined following the procedure of Matthey (1945) and by direct measurement of arm-lengths. The skin and skeleton of the shrew (orig. No. 47985) were prepared by standard methods and deposited in the collection of the Section of Mammals, Burke Memorial Washington State Museum, University of Washington, No. 38109.

Coordinates (approximate) for localities mentioned in the literature cited were established from Atlas SSSR (Glavnoe upravlenie geodezi i kartografii pri Sovete Ministerov SSSR, Moskva, 1969); in some cases, spellings in the published papers differed slightly from those of the Atlas.

### Results

The diploid complement (32) consisted of the following: 24 chromosomes with centromere median to submedian in location (pairs 1–12; range of arm-ratio 1.1 to 2.6); 6 chromosomes with centromere submedian to subterminal (pairs 13–15; arm-ratio 2.7 to 6.1); and 2 chromosomes with centromere in the terminal area (pair 16; arm-ratio > 10). The findings of Meylan & Hausser (1991) and other published data (e.g., Ivanitskaia & Kozlovskii 1983) concerning closely related taxa belonging to the *araneus*-group in Eurasia indicate clearly that the sex-chromosomes of the female studied are the two submetacentric elements of

greatest size in the complement (first pair in the karyograms, Fig. 1A, B). The FN (autosomes plus sex-chromosomes) was determined as 62. We conclude that the shrew studied by Meylan & Hausser (1991) is karyotypically identical with our specimen from Alaska, except for the obvious sex-related difference.

### Discussion

Jackson (1928) defined morphological characters that distinguish *Sorex arcticus* and *S. tundrensis* in North America, but later investigators were of the opinion that those taxa could be differentiated only at the infraspecific level (Rausch 1953, Bee & Hall 1956, Hall & Kelson 1959). With placement of *S. tundrensis* in synonymy with *S. arcticus*, the latter would have a continuous distribution in North America from the Atlantic coast in southeastern Canada to the northern and western coasts of Alaska (as shown by Hall 1981). Youngman (1975) reassessed the cranial characters of the two taxa and confirmed Jackson's (1928) conclusion that *S. arcticus* and *S. tundrensis* are separate species. He also determined that the two are allopatric, their geographic ranges separated by a relatively narrow area in the western part of the Yukon Territory. A disjunct region in southeastern Canada (New Brunswick and Nova Scotia) is occupied by a taxon designated *S. a. maritimensis* Smith, 1939, whose chromosomal characteristics suggest that it may represent an independent species (Volobouev & van Zyll de Jong 1988).

In Eurasia, Stroganov (1936) compared *S. araneus ultimus* G. M. Allen, 1914, described from Nijni Kolym'sk (=Nizhnekolym'sk) on the lower Kolyma River (68°30'N, 161°E), and concluded that it was conspecific with *S. tundrensis*. He recognized two additional subspecies, *S. t. petshorae* Ognev, 1922 (type locality: the lower reaches of the Pechora River, Arkhangel'sk Oblast', lying in northern European Russia, ca. 68°N,



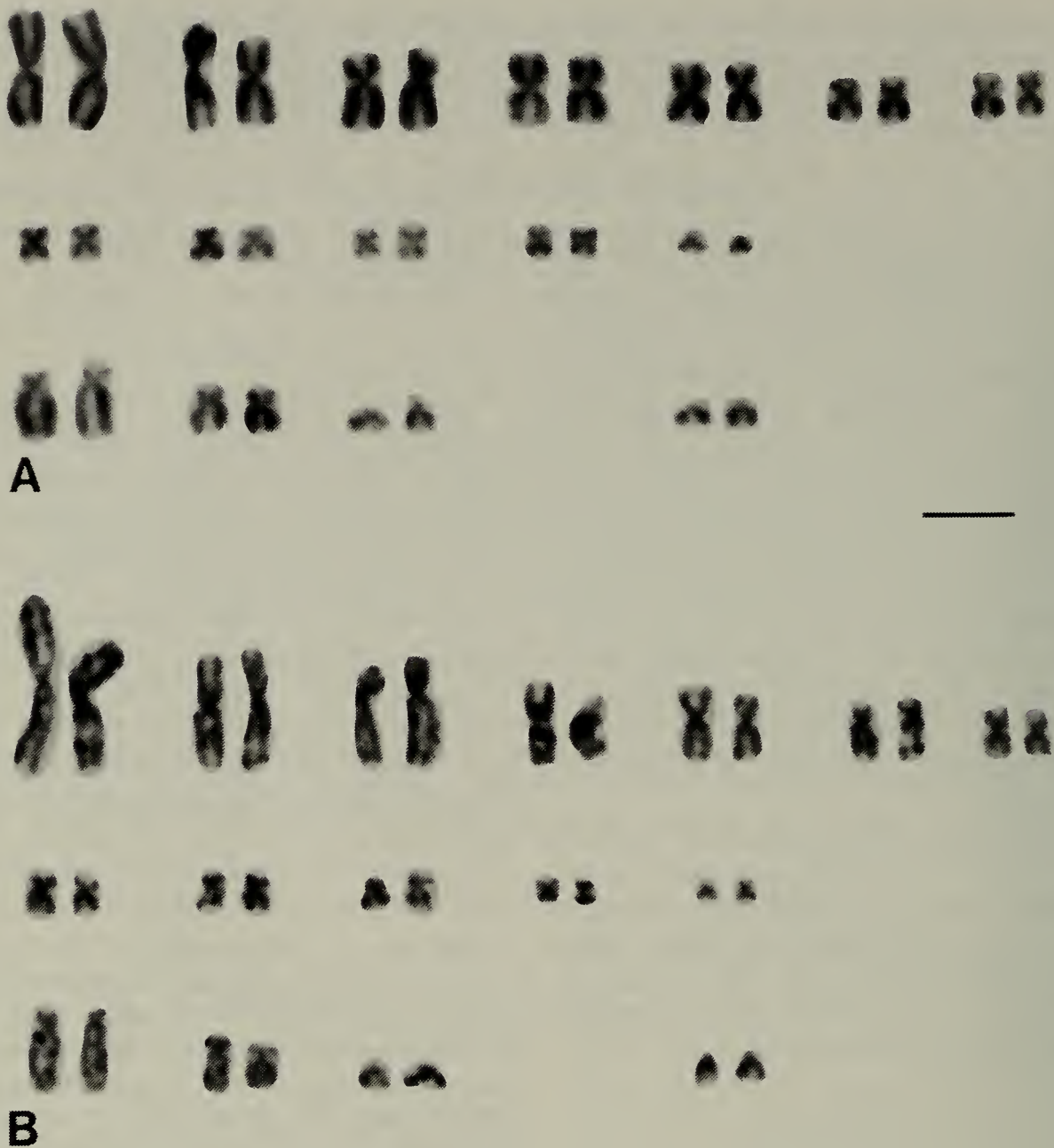


Fig. 1. Karyotype of *Sorex tundrensis*, female.  $2N = 32$ . Scale-line has value of  $5 \mu\text{m}$ . A. Chromosomes consist of 12 pairs of metacentric-submetacentric, 3 pairs subtelocentric, and 1 pair acrocentric. The largest elements in the complement (first pair) are the X-chromosomes. Standard Giemsa stain. B. Karyogram with chromosomes (arranged as in A) banded by the Giemsa-method.

$54^{\circ}\text{E}$ ) and *S. t. middendorfi* Ognev, 1933 (type locality: on the Angara River, Irkutsk Oblast', south-central Siberia, ca.  $56^{\circ}\text{N}$ ,  $103^{\circ}\text{E}$ ), and described a third, *S. t. europaeus* Stroganov, 1936, from Chun Lake on the Kola Peninsula ( $68^{\circ}\text{N}$ ,  $36^{\circ}\text{E}$ ). Stroganov stated (p. 131) (our translation) that "Here it is interesting to note that the Anadyr' *Sorex tundrensis ultimus* on the basis of systematic characters (structure of the skull and

measurements) stands much closer to the American *S. t. tundrensis* than to any other palaeartic forms such as *S. t. middendorfi* and others." Ognev (1941, cited in Okhotina 1983) reached the same conclusion after comparing specimens from the valley of the Anadyr' (ca.  $65^{\circ}\text{N}$ ,  $171^{\circ}\text{E}$ ) and from Alaska. Allen also stated (1914:52), in his remarks concerning *S. araneus ultimus* with reference to pelage-color, that "The same

condition is found in *S. tundrensis* of northern Alaska, which is clearly a New World derivative of the present species.”

In accordance with the taxonomic concept of Hall & Kelson (1959) and others in North America, mammalogists in the Soviet Union accepted the name *arcticus* for the Eurasian taxa that previously had been designated *S. tundrensis*. Not until the diploid number of chromosomes and FN for *S. arcticus* had been defined in Canada (Meylan 1968) were more definitive comparisons possible. Kozlovskii (1971) discussed findings in some Eurasian shrews with reference to the karyotype of *S. arcticus*, and determined that the palaeartic taxa were distinct and apparently represented morphologically similar sibling species. On the basis of all data, Vorontsov & Liapunova (1976) concluded that *S. arcticus* is not an holarctic species, and their judgment was confirmed by the detailed comparisons made by Ivanitskaia & Kozlovskii (1983), who pointed out that *Sorex tundrensis* was the applicable name for all of the Eurasian taxa that had been erroneously designated *S. arcticus*. Other investigators reached the same conclusion on the basis of macromorphological criteria (Junge & Hoffmann 1981, Okhotina 1983, Junge et al. 1983). The allozyme electrophoretic study by George (1988) also indicated specific distinction. The karyotype of *S. arcticus* in Canada was described in detail by Meylan & Hausser (1973).

Shrews referred to *S. tundrensis* occur widely in Eurasia: northeastern Europe; northern and middle Asia, including the northern part of Mongolia; northeastern regions of China; and the northern part of Korea (Okhotina 1984). Information concerning the distribution of nominal subspecies and synonymies has been provided by Gureev (1981), Junge et al. (1983), and Pavlinov & Rossolimo (1987). Okhotina (1984) recognized four subspecies of *S. tundrensis* in the Far East of the former Soviet Union: *S. t. tundrensis* Merriam, 1900 (= *S. arcticus*

*borealis* Kashchenko, 1905 = *S. a. buxtoni* J. A. Allen, 1903); *S. t. baikalensis* Ognev, 1913 (= *S. arcticus baikalensis* Ognev, 1913); *S. t. stroganovi* Okhotina, 1983 (= *S. arcticus* ssp. nov. Stroganov, 1957); and *S. t. parvicaudatus* Okhotina, 1976 (= *S. arcticus parvicaudatus* Okhotina, 1976). According to Okhotina's concept, the distribution of the nominate subspecies of *S. tundrensis* in Eurasia would include northeastern Siberia from Chukotka southward to the western shore of the Amur River (Primorsk region).

Chromosomal characteristics have been defined for shrews designated *S. tundrensis* from several of the Eurasian localities: vicinity of Uskovo, Novokuznetsk region (53°40'N, 87°E), Kemerovsk Oblast', and vicinity of Irkutsk (52°15'N, 104°E) (Kozlovskii 1971); Boguchan, on the Chun River (57°40'N, 96°E), Krasnoiarsk Krai, and Bakchar (57°6'N, 82°E), Tomsk Oblast' (Fedyk & Ivanitskaia 1972); Novosibirsk (55°4'N, 83°E) (Kral & Radjabli 1976); vicinity of Main (53°N, 91°30'E), Krasnoiarsk Krai (Aniskin & Volobuev 1980); vicinity of Razdol'noe (43°34'N, 132°E), Primorsk Krai; shore of Chaunsk Gulf (68°45'N, 170°E) and vicinity of Stokovyi Ten'kinsk, Magadansk Oblast'; Katon-Karagai (49°10'N, 85°30'E), East Kazakh Oblast'; and Moneron Island (at the southern end of Sakhalin Island), Sakhalinsk Oblast' (Ivanitskaia & Kozlovskii 1983); two localities in the Seleginsk Aimak in northern Mongolia (ca. 50°N, south of Lake Baikal) (Ivanitskaia & Malygin 1985); and Zveringolovskoe (54°30'N, 64°45'E), Kurgansk Oblast', and vicinity of Abakan (53°38'N, 91°30'E), Krasnoiarsk Krai (Ivanitskaia et al. 1986). Ivanitskaia & Kozlovskii (1983, table 1) summarized the data on diploid number, fundamental number, and morphological characteristics of autosomes for shrews from the aforementioned localities, with exception of those reported by Ivanitskaia & Malygin (1985) and Ivanitskaia et al. (1986).

The diploid number of chromosomes in



males of the Eurasian shrews referred to *Sorex tundrensis* has been found to range from 31 to 40, with fundamental numbers (autosomes) of 52 or 54. Because of the trivalent sex-chromosome in males, diploid numbers in females were typically one less. In some Eurasian taxa, polymorphism has been observed in chromosome-pairs 1, 2, 4, and 6 (see Ivanitskaia & Kozlovskii 1983, table 1). Aniskin & Volobuev (1980) and Ivanitskaia et al. (1986) suggested that such variation in the designated homologues was due to Robertsonian translocations.

While the diploid number of chromosomes of *S. t. tundrensis* from the Yukon Territory and Alaska is the same as that of animals from some populations in the Palearctic, e.g., Novosibirsk (middle Asia) and Magadansk Oblast' (northeasternmost Siberia), the morphological differences in the chromosomal complements between Eurasia and North America are well defined. The autosomal complement of the Alaskan female (Fig. 1) consisted of 14 pairs of bi-armed chromosomes ranging from metacentric to subtelocentric, and a single pair of acrocentrics, whereas complements of the Siberian specimens may have a larger component of acrocentric elements and/or a disparate diploid number (e.g., those from Moneron Island and Primorsk Krai). The fundamental number, established on the basis of arm-ratios, of *S. tundrensis* from Alaska is thus greater (58, as compared with 52 or 54 in the Eurasian shrews). For the male specimen from the Yukon Territory, Meylan & Hausser (1991) obtained an FN of 54, but their preparations (Meylan & Hausser, fig. 1) probably did not permit accurate measurement of all elements of the complement, and they designated three pairs as acrocentric. The value of the FN as determined by them would explain their conclusion that taxa referred to *S. tundrensis* in Eurasia must be conspecific with that in North America. With relation to our findings, should future studies demonstrate that an additional autosomal pair (chromo-

somes with arm-ratio of about 6) is better classified as acrocentric, the FN of the North American taxon would be reduced to 56, still greater than any recorded in Eurasian animals. The difference in total number of chromosomal arms indicates a significant degree of evolutionary distance between the North American and Eurasian taxa, and in combination with morphological dissimilarities existing between the respective karyotypes, permits the conclusion that *Sorex tundrensis* is limited in occurrence to the Nearctic. The taxa in Eurasia that previously have been referred to *S. tundrensis* appear to make up a complex of sibling species, as has been suggested by Kozlovskii (1971) and others, among which karyotypic differences seem smaller than those between them and *S. tundrensis*. Further comparisons using Giemsa-banding and other methods will be required to determine homologues of chromosomes in the different populations, including *S. tundrensis* in North America.

Rand (1954) perceived that *Sorex arcticus* and *S. tundrensis* evidently have been derived from two separate Pleistocene dispersals of shrews of the *araneus*-group into North America via Beringia. The present geographic range of *S. arcticus*, the earlier migrant, is a consequence of its northward expansion during post-glacial time, whereas that of *S. tundrensis* is still approximately within the North American portion of the former Beringian Refugium.

We undertook field-work at various localities in south-central and eastern Alaska during 1988–1992. Shrews were numerous in south-central Alaska during August 1989–1990, but according to our findings, populations consisted mostly of *S. cinereus* Kerr and *S. monticolus* Merriam; we obtained only the single specimen of *S. tundrensis*. Shrews decreased in numbers after 1990, and in 1992 were at the lowest density observed. A similar pattern of change in numbers was seen in eastern Alaska where, with the exception of a single specimen of *S. hoyi*

(Baird), the same two species made up our collections. Factors that influence changes in numerical densities of shrews are not understood, but interspecific competition in probably marginal habitat at the southern limits of the range of *S. tundrensis* was perhaps significant.

### Acknowledgments

We express our sincere gratitude to Mr. L. Alan LeMaster and Ms. Shirley LeMaster, Gakona, Alaska, whose generous provision of space for laboratory-procedures contributed significantly to our work.

### Literature Cited

- Allen, G. M. 1914. Mammals. Pp. 49–66 in Notes on the birds and mammals of the arctic coast of East Siberia.—Proceedings of the New England Zoological Club 5:1–66.
- Aniskin, V. M., & V. T. Volobuev. 1980. Khromosomnyi polimorfizm v sibirskikh populiatsiiakh burozubok *araneus-arcticus* kompleksa (Insectivora–Soricidae). Soobshchenie II. Saianskaia populiatsiia arkticheskoi burozubki *Sorex arcticus* Kerr (1792).—Genetika 16:2171–2175.
- Bee, J. W., & E. R. Hall. 1956. Mammals of northern Alaska on the Arctic Slope.—University of Kansas, Museum of Natural History, Miscellaneous Publications 8:1–309.
- Fedyk, S., & E. Iu. Ivanitskaia. 1972. Chromosomes of Siberian shrews.—Acta Theriologica 17:475–492.
- George, S. B. 1988. Systematics, historical biogeography, and evolution of the genus *Sorex*.—Journal of Mammalogy 69:443–461.
- Gureev, A. A. 1981. Nasekomoidyne. Pp. 7–30 in I. M. Gromov & G. I. Baranova, eds., Katalog mlekopitaiushchikh SSSR. Pliotsen-Sovremenost'. Nauka, Leningrad, 456 pp.
- Hall, E. R. 1981. The mammals of North America. 2nd edition. Vol. 1. John Wiley & Sons, New York, 600 + 90 pp.
- , & K. R. Kelson. 1959. The mammals of North America. Vol. 1. Ronald Press, New York, 546 + 79 pp.
- Ivanitskaia, E. Iu., & A. I. Kozlovskii. 1983. Kariologicheskie dokazatel'stva otsutstviia v palearktike arkticheskoi burozubki (*Sorex arcticus*).—Zoologicheskii Zhurnal 62:399–408.
- , ——, V. N. Orlov, Iu. M. Koval'skaia, & M. I. Baskevich. 1986. Novye dannye o kariotypakh zemleroek-burozubok fauny SSSR (*Sorex*, Soricidae, Insectivora).—Zoologicheskii Zhurnal 65:1228–1236.
- , & V. M. Malygin. 1985. Khromosomnye nabory nasekomoidydykh mlekopitaiushchikh Mongolii.—Biulleten' Moskovskogo Obshchestva Ispytatelei Prirody 90:15–23.
- Jackson, H. T. T. 1928. A taxonomic review of the American long-tailed shrews.—North American Fauna 51:1–238.
- Junge, J. A., & R. S. Hoffmann. 1981. An annotated key to the long-tailed shrews (genus *Sorex*) of the United States and Canada, with notes on Middle American *Sorex*. Occasional Papers of the Museum of Natural History, University of Kansas, Lawrence, Kansas 94:1–48.
- , ——, & R. W. Debry. 1983. Relationships within the holarctic *Sorex arcticus*–*Sorex tundrensis* species complex.—Acta Theriologica 28:339–350.
- Kozlovskii, A. I. 1971. Kariotipy i sistematika nekotorykh populiatsii zemleroek, obychno otnosimykh k arkticheskoi burozubke—*Sorex arcticus* (Insectivora, Soricidae).—Zoologicheskii Zhurnal 50:756–762.
- Král, B., & S. I. Radjabli. 1976. Karyotypes and G-bands of western Siberian shrews *Sorex arcticus* and *S. araneus* (Soricidae, Insectivora).—Zoologické Listy 25:327–334.
- Levan, A., K. Fredga, & A. A. Sandberg. 1964. Nomenclature for centromeric position on chromosomes.—Hereditas 52:200–220.
- Matthey, R. 1945. L'évolution de la formule chromosomiale chez les vertébrés.—Experientia 1:50–60, 78–86.
- Meylan, A. 1968. Formules chromosomiques de quelques petits mammifères nord-américains.—Revue Suisse de Zoologie 75:691–696.
- , & J. Hausser. 1973. Les chromosomes des *Sorex* du groupe *araneus-arcticus* (Mammalia, Insectivora).—Zeitschrift für Säugetierkunde 38:143–158.
- , & —— . 1991. The karyotype of the North American *Sorex tundrensis* (Mammalia, Insectivora).—Mémoires de la Société Vaudoise des Sciences Naturelles 19:125–129.
- Okhotina, M. V. 1983. Taksonomicheskaiia revisiia *Sorex arcticus* Kerr. 1792 (Soricidae, Insectivora). Zoologicheskii Zhurnal 62:409–417.
- . 1984. Otriad Insectivora Bowdich, 1821—nasekomoidydyne. Pp. 31–72 in V. G. Krivosheev, ed., Nazemnye mlekopitaiushchie dal'nego vostoka SSSR. Opredelitel'. Nauka, Moskva, 358 pp.
- Pavlinov, I. Ia., & O. L. Rossolimo. 1987. Systematika mlekopitaiushchikh SSSR. Izdat. Moskovskogo Universiteta, Moskva, 284 pp.



- Rand, A. L. 1954. The ice age and mammal speciation in North America.—*Arctic* 7:31–35.
- Rausch, R. L. 1953. On the status of some arctic mammals.—*Arctic* 6:91–148.
- , & V. R. Rausch. 1975. Taxonomy and zoogeography of *Lemmus* spp. (Rodentia: Arvicolinae), with notes on laboratory-reared lemmings.—*Zeitschrift für Säugetierkunde* 40:8–34.
- Seabright, M. 1972. The use of proteolytic enzymes for the mapping of structural rearrangements in the chromosomes of man.—*Chromosoma* 36:204–210.
- Stroganov, S. U. 1936. Fauna mlekopitaiushchikh Valdaiskoi vozvyshennosti.—*Zoologicheskii Zhurnal* 15:128–142.
- Volobouev, V. T., & C. G. van Zyll de Jong. 1988. The karyotype of *Sorex arcticus maritimensis* (Insectivora, Soricidae) and its systematic implications.—*Canadian Journal of Zoology* 66:1968–1972.
- Vorontsov, N. N., & E. A. Liapunova. 1976. Genetika i problemy transberingiiskikh sviazei golarkticheskikh mlekopitaiushchikh. Pp. 337–353 in V. L. Kontrimavichus, ed., *Beringia v Keinozoe*. Akademiia Nauk SSSR, Vladivostok, 594 pp.
- Youngman, P. M. 1975. Mammals of the Yukon Territory.—National Museum of Natural Sciences, Publications in Zoology, No. 10, 192 pp.

Section of Mammals, Burke Memorial Washington State Museum, DB-10, and Department of Comparative Medicine, SB-42, School of Medicine, University of Washington, Seattle, Washington 98195, U.S.A.